ATENT COOPERATION TREA

PCT

REC'D 29 JUN 2000
WIPO PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

16

Applicant's or agent's file reference NEST 72 PCT	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
International application No. PCT/FI99/00153	International filing date *(day/month/year)* 26.02.1999	Priority date *(day/month/year)* 27.02.1998
International Patent Classification (IPC) or national classification and IPC7 C 10 J 3/54, B 01 J 8/26		
Applicant Fortum OYJ		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of [4] 5 sheets, including this cover sheet.

☐ This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

These annexes consist of a total of _____ sheets.

3. This report contains indications relating to the following items:

- I ☒ Basis of the report
- II ☐ Priority
- III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- IV ☐ Lack of unity of invention
- V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- VI ☒ Certain documents cited
- VII ☐ Certain defects in the international application
- VIII ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
22.09.1999	20.06.2000
Name and mailing address of the IPEA/SE Patent- och registreringsverket Box 5055 S-102 42 STOCKHOLM Telex 17978 PATOREG-S Facsimile No. 08-667 72 88	Authorized officer Anders Bruun/ELY Telephone No. 08-782 25 00

Form PCT/IPEA/409 (cover sheet) (January 1994)

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

[redacted]national application No.
PCT/FI99/00153

I. Basis of the report

1. This report has been drawn on the basis of *(Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments.)*:

☒ the international application as originally filed.

☐ the description, pages _____ , as originally filed,
pages _____ , filed with the demand,
pages _____ , filed with the letter of _____ ,
pages _____ , filed with the letter of _____ .

☐ the claims, Nos. _____ , as originally filed,
Nos. _____ , as amended under Article 19,
Nos. _____ , filed with the demand,
Nos. _____ , filed with the letter of _____ ,
Nos. _____ , filed with the letter of _____ .

☐ the drawings, ~~sheets~~/fig _____ , as originally filed,
~~sheets~~/fig _____ , filed with the demand
~~sheets~~/fig _____ , filed with the letter of _____ ,
~~sheets~~/fig _____ , filed with the letter of _____ .

2. The amendments have resulted in the cancellation of:

☐ the description, pages _____
☐ the claims, Nos. _____
☐ the drawings, ~~sheets~~/fig _____

3. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the supplemental Box (Rule 70.2(c)).

4. Additional observations, if necessary:

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

national application No.
PCT/FI99/00153

V. Resoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	1-20	YES
	Claims		NO
Inventive step (IS)	Claims	1-20	YES
	Claims		NO
Industrial applicability (IA)	Claims	1-20	YES
	Claims		NO

2. Citations and explanations

The invention relates to a process and an apparatus for thermal conversion of biomass and organic wastes. In the process according to claim 1, the feedstock is fed into a fluidised-bed reactor wherein said feedstock is mixed with fluidised particles and converted to hydrocarbon products. The fluidised particles are regenerated in a regenerator. The process is characterised by the use of a regenerator and a reactor which are equipped with multi inlet cyclones to separate solids from gas and in that the regenerator is concentrically fitted in respect of the reactor. The apparatus according to claim 16 consists of a drying unit in addition to a reactor and a regenerator arranged as described above.

Most relevant document cited in the International Search Report:

D1: US 2 525 925

D1 describes an arrangement for production of hydrocarbons in a fluidised bed-reactor which have an reaction zone (10) and a regeneration zone (12) for the fluidising particles concentrically fitted to each other (see column 2, line 10 - column 4, line 13).

.../...

Supplemental Box
(To be used when the space in any of the preceding boxes is not sufficient)

Continuation of: V.

The arrangement described in D1 differs from the invention according to the independent claims 1 and 16 in that it is designed for liquid fuel meanwhile the present invention is designed for solid, carbonaceous feedstock. There is nowhere indicated in D1 that the arrangement should be used for anything else but catalytic cracking of petroleum. Since the processing of liquid or solid feedstock to hydrocarbon products usually deals with different problems to be solved when performing the process it is not considered to be obvious for a person skilled in the art to use a method designed for liquid fuel to be adapted for a process designed for solid fuel.

Hence, the process according to independent claim 1 and thereupon depending claims 2-14 and the apparatus according to independent claim 15 and thereupon depending claims 16-20 are regarded to be novel, involve an inventive step and to have industrial applicability.

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/FI99/00153

VI. Certain documents cited

1. Certain published documents (Rule 70.10)

Application No. Patent No.	Publication date *(day/month/year)*	Filing date *(day/month/year)*	Priority date (valid claim) *(day/month/year)*
WO 9808600 A1	05/03/98	01/09/97	30/08/96

2. Non-written disclosures (Rule 70.9)

Kind of non-written disclosure	Date of non-written disclosure *(day/month/year)*	Date of written disclosure referring to non-written disclosure *(day/month/year)*

PCT

REQUEST

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty.

For receiving Office use only

International Application No.

International Filing Date

Name of receiving Office and "PCT International Application"

Applicant's or agent's file reference *(if desired) (12 characters maximum)* NEST 72 PCT

Box No. I TITLE OF INVENTION

Process for pyrolysing carbonaceous feedstocks

Box No. II APPLICANT

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

NESTE OYJ
Keilaniemi
FIN-02150 Espoo
Finland

☐ This person is also inventor.

Telephone No.

Facsimile No.

Teleprinter No.

State *(that is, country)* of nationality: Finland

State *(that is, country)* of residence: Finland

This person is applicant for the purposes of: ☐ all designated States ☒ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

HILTUNEN, Jyrki
Jänissuontie 28
FIN-04130 Sipoo
Finland

This person is:

☐ applicant only

☒ applicant and inventor

☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality: Finland

State *(that is, country)* of residence: Finland

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

☒ Further applicants and/or (further) inventors are indicated on a continuation sheet.

Box No. IV AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE

The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as: ☒ agent ☐ common representative

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

SEPPO LAINE OY
Itämerenkatu 3 B
FIN-00180 Helsinki
Finland

Telephone No. +358-9-68 59 560

Facsimile No. +358-9-68 595 610

Teleprinter No.

☐ **Address for correspondence:** Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.

Continuation of Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

If none of the following sub-boxes is used, this sheet should not be included in the request.

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

GUST, Steven
Pormestarinkatu 10 C 67
FIN-06100 Porvoo
Finland

This person is:
- [ ] applicant only
- [X] applicant and inventor
- [ ] inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality: Canada

State *(that is, country)* of residence: Finland

This person is applicant for the purposes of:
- [ ] all designated States
- [ ] all designated States except the United States of America
- [X] the United States of America only
- [ ] the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

NIEMINEN, Jukka-Pekka
Viertokuja 1 G 27
FIN-06400 Porvoo
Finland

This person is:
- [ ] applicant only
- [X] applicant and inventor
- [ ] inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality: Finland

State *(that is, country)* of residence: Finland

This person is applicant for the purposes of:
- [ ] all designated States
- [ ] all designated States except the United States of America
- [X] the United States of America only
- [ ] the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

This person is:
- [ ] applicant only
- [ ] applicant and inventor
- [ ] inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality:

State *(that is, country)* of residence:

This person is applicant for the purposes of:
- [ ] all designated States
- [ ] all designated States except the United States of America
- [ ] the United States of America only
- [ ] the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

This person is:
- [ ] applicant only
- [ ] applicant and inventor
- [ ] inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* f nationality:

State *(that is, country)* of residence:

This person is applicant for the purp ses f:
- [ ] all designated States
- [ ] all designated States except the United States of America
- [ ] the United States of America only
- [ ] the States indicated in the Supplemental Box

- [ ] Further applicants and/or (further) invent rs are indicated n another continuati n sheet.

Box No.V DESIGNATION OF STATES

The following designations are hereby made under Rule 4.9(a) *(mark the applicable check-boxes; at least one must be marked)*:

Regional Patent

- [X] AP **ARIPO Patent:** GH Ghana, GM Gambia, KE Kenya, LS Lesoth , MW Malawi, SD Sudan, SZ Swaziland, UG Uganda, ZW Zimbabwe, and any other State which is a Contracting State of the Harare Protocol and of the PCT
- [X] EA **Eurasian Patent:** AM Armenia, AZ Azerbaijan, BY Belarus, KG Kyrgyzstan, KZ Kazakhstan, MD Republic of M ldova, RU Russian Federation, TJ Tajikistan, TM Turkmenistan, and any other State which is a C ntracting State of the Eurasian Patent Conventi n and f the PCT
- [X] EP **European Patent:** AT Austria, BE Belgium, CH and LI Switzerland and Liechtenstein, CY Cyprus, DE Germany, DK Denmark, ES Spain, FI Finland, FR France, GB United Kingdom, GR Greece, IE Ireland, IT Italy, LU Luxembourg, MC Monaco, NL Netherlands, PT Portugal, SE Sweden, and any other State which is a Contracting State of the European Patent Convention and of the PCT
- [X] OA **OAPI Patent:** BF Burkina Faso, BJ Benin, CF Central African Republic, CG Congo, CI Côte d'Ivoire, CM Cameroon, GA Gabon, GN Guinea, GW Guinea-Bissau, ML Mali, MR Mauritania, NE Niger, SN Senegal, TD Chad, TG Togo, and any other State which is a member State of OAPI and a Contracting State of the PCT *(if other kind of protection or treatment desired, specify on dotted line)* .....

National Patent *(if other kind of protection or treatment desired, specify on dotted line)*:

- [X] AL Albania .....
- [X] AM Armenia .....
- [X] AT Austria .....
- [X] AU Australia .....
- [X] AZ Azerbaijan
- [X] BA Bosnia and Herzegovina .....
- [X] BB Barbados
- [X] BG Bulgaria .....
- [X] BR Brazil .....
- [X] BY Belarus .....
- [X] CA Canada
- [X] CH and LI Switzerland and Liechtenstein
- [X] CN China .....
- [X] CU Cuba .....
- [X] CZ Czech Republic .....
- [X] DE Germany .....
- [X] DK Denmark .....
- [X] EE Estonia .....
- [X] ES Spain .....
- [X] FI Finland .....
- [X] GB United Kingdom
- [X] GD Grenada
- [X] GE Georgia .....
- [X] GH Ghana .....
- [X] GM Gambia
- [X] HR Croatia .....
- [X] HU Hungary .....
- [X] ID Indonesia
- [X] IL Israel .....
- [X] IN India .....
- [X] IS Iceland
- [X] JP Japan .....
- [X] KE Kenya .....
- [X] KG Kyrgyzstan .....
- [X] KP Democratic People's Republic of Korea .....
- [X] KR Republic of Korea .....
- [X] KZ Kazakhstan .....
- [X] LC Saint Lucia
- [X] LK Sri Lanka
- [X] LR Liberia
- [X] LS Lesotho .....
- [X] LT Lithuania
- [X] LU Luxembourg
- [X] LV Latvia
- [X] MD Republic of Moldova .....
- [X] MG Madagascar .....
- [X] MK The former Yugoslav Republic of Macedonia .....
- [X] MN Mongolia
- [X] MW Malawi .....
- [X] MX Mexico .....
- [X] NO Norway
- [X] NZ New Zealand .....
- [X] PL Poland .....
- [X] PT Portugal .....
- [X] RO Romania
- [X] RU Russian Federation .....
- [X] SD Sudan
- [X] SE Sweden
- [X] SG Singapore
- [X] SI Slovenia .....
- [X] SK Slovakia .....
- [X] SL Sierra Leone
- [X] TJ Tajikistan .....
- [X] TM Turkmenistan .....
- [X] TR Turkey .....
- [X] TT Trinidad and Tobago .....
- [X] UA Ukraine .....
- [X] UG Uganda .....
- [X] US United States of America .....
- [X] UZ Uzbekistan .....
- [X] VN Viet Nam .....
- [X] YU Yugoslavia .....
- [X] ZW Zimbabwe .....

Check-boxes reserved for designating States (for the purposes of a national patent) which have become party to the PCT after issuance of this sheet:

- [ ] .....
- [ ] .....
- [ ] .....

Precautionary Designation Statement: In addition to the designations made above, the applicant also makes under Rule 4.9(b) all other designations which would be permitted under the PCT except any designation(s) indicated in the Supplemental Box as being excluded from the scope f this statement. The applicant declares that th se additional designations are subject to confirmation and that any designation which is not confirmed before the expirati n of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit. *(Confirmation of a designation consists of the filing of a notice specifying that designation and the payment of the designation and confirmation fees. Confirmation must reach the receiving Office within the 15-month time limit.)*

Box No. VI PRIORITY CLAI ☐ Further priority c are indicated in the Supplemental Box.

Filing date of earlier application (day/month/year)	Number of earlier application	Where earlier application is: national application: country	regional application:* regional Office	international application: receiving Office
item (1) (27.02.98) 27 February 1998	980456	FI		
item (2)				
item (3)				

☒ The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) *(only if the earlier application was filed with the Office which for the purposes of the present international application is the receiving Office)* identified above as item(s): (1)

* *Where the earlier application is an ARIPO application, it is mandatory to indicate in the Supplemental Box at least one country party to the Paris Convention for the Protection of Industrial Property for which that earlier application was filed (Rule 4.10(b)(ii)). See Supplemental Box.*

Box No. VII INTERNATIONAL SEARCHING AUTHORITY

Choice of International Searching Authority (ISA) *(if two or more International Searching Authorities are competent to carry out the international search, indicate the Authority chosen; the two-letter code may be used):* ISA / SE

Request to use results of earlier search; reference to that search *(if an earlier search has been carried out by or requested from the International Searching Authority):*
Date *(day/month/year)* Number Country *(or regional Office)*

Box No. VIII CHECK LIST; LANGUAGE OF FILING

This international application contains the following **number of sheets**:

request	:	4
description (excluding sequence listing part)	:	13
claims	:	3
abstract	:	1
drawings	:	2
sequence listing part of description	:	-
Total number of sheets	:	23

This international application is **accompanied by** the item(s) marked below:

1. ☒ fee calculation sheet
2. ☒ separate signed power of attorneys (2)
3. ☐ copy of general power of attorney; reference number, if any:
4. ☐ statement explaining lack of signature
5. ☐ priority document(s) identified in Box No. VI as item(s):
6. ☐ translation of international application into (language):
7. ☐ separate indications concerning deposited microorganism or other biological material
8. ☐ nucleotide and/or amino acid sequence listing in computer readable form
9. ☒ other *(specify)*: copy of official action

Figure of the drawings which should accompany the abstract: 1

Language of filing of the international application: English

Box No. IX SIGNATURE OF APPLICANT OR AGENT

Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the request).

For the Applicants

Seppo Laine Oy

Christoffer Sundman

For receiving Office use only

1. Date of actual receipt of the purported international application:	2. Drawings: ☐ received: ☐ not received:
3. Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application:	
4. Date f timely receipt of the required corrections under PCT Article 11(2):	
5. Internati nal Searching Authority (if two r more are competent): ISA /	6. ☐ Transmittal of search copy delayed until search fee is paid.

For Internati nal Bureau use nly

Date of receipt of the record copy by the International Bureau:

The demand must be filed directly with the competent International Preliminary Examining Authority or, if two or more Authorities are competent, with the one chosen by the applicant. The full name or two-letter code of that Authority may be indicated by the applicant on the line below:

IPEA/ SE

PCT

CHAPTER II

DEMAND

under Article 31 of the Patent Cooperation Treaty:
The undersigned requests that the international application specified below be the subject of international preliminary examination according to the Patent Cooperation Treaty and hereby elects all eligible States (except where otherwise indicated).

For International Preliminary Examining Authority use only

Identification of IPEA	Date of receipt of DEMAND

Box No. I IDENTIFICATION OF THE INTERNATIONAL APPLICATION

Applicant's or agent's file reference: NEST 72 PCT

International application No.	International filing date *(day/month/year)*	(Earliest) Priority date *(day/month/year)*
PCT/FI99/00153	26 February 1999 (26.02.99)	27 February 1998 (27.2.98)

Title of invention: Process for pyrolysing carbonaceous feedstocks

Box No. II APPLICANT(S)

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

NESTE OYJ
Keilaniemi
FIN-02150 Espoo
Finland

Telephone No.:

Facsimile No.:

Teleprinter No.:

State *(that is, country)* of nationality: Finland

State *(that is, country)* of residence: Finland

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

HILTUNEN, Jyrki
Jänissuontie 28
FIN-04130 Sipoo
Finland

State *(that is, country)* of nationality: Finland

State *(that is, country)* of residence: Finland

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

GUST, Steven
Pormestarinkatu 10 C 67
FIN-06100 Porvoo
Finland

State *(that is, country)* of nationality: Canada

State *(that is, country)* of residence: Finland

[X] Further applicants are indicated on a continuation sheet.

Sheet No. 2.

International application No.
PCT/FI99/00153

Continuation of Box No. II APPLICANT(S)

If none of the following sub-boxes is used, this sheet should not be included in the demand.

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

NIEMINEN, Jukka-Pekka
Viertokuja 1 G 27
FIN-06400 Porvoo
Finland

State *(that is, country)* of nationality:	State *(that is, country)* of residence:
Finland	Finland

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

State *(that is, country)* of nationality:	State *(that is, country)* of residence:

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

State *(that is, country)* of nationality:	State *(that is, country)* of residence:

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

State *(that is, country)* of nationality:	State *(that is, country)* of residence:

☐ Further applicants are indicated on another continuation sheet.

[redacted]tional application No.
[redacted]T/FI99/00153

Box No. III AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE

The following person is [X] agent [ ] common representative

and [X] has been app inted earlier and represents the applicant(s) also for internati nal preliminary examination.

[ ] is hereby appointed and any earlier appointment of (an) agent(s)/common representative is hereby rev ked.

[ ] is hereby appointed, specifically for the procedure before the International Preliminary Examining Authority, in addition to the agent(s)/common representative appointed earlier.

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

SEPPO LAINE OY
Itämerenkatu 3 B
FIN-00180 Helsinki
Finland

Telephone No.: +358-9-68 59 560

Facsimile No.: +358-9-68 595 610

Teleprinter No.:

[ ] **Address for correspondence:** Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.

Box No. IV BASIS FOR INTERNATIONAL PRELIMINARY EXAMINATION

Statement concerning amendments:*

1. The applicant wishes the international preliminary examination to start on the basis of:

[X] the international application as originally filed

the description
[ ] as originally filed
[ ] as amended under Article 34

the claims
[ ] as originally filed
[ ] as amended under Article 19 (together with any accompanying statement)
[ ] as amended under Article 34

the drawings
[ ] as originally filed
[ ] as amended under Article 34

2. [ ] The applicant wishes any amendment to the claims under Article 19 to be considered as reversed.

3. [ ] The applicant wishes the start of the international preliminary examination to be postponed until the expiration of 20 months from the priority date unless the International Preliminary Examining Authority receives a copy of any amendments made under Article 19 or a notice from the applicant that he does not wish to make such amendments (Rule 69.1(d)). *(This check-box may be marked only where the time limit under Article 19 has not yet expired.)*

* Where no check-box is marked, international preliminary examination will start on the basis of the international application as originally filed or, where a copy of amendments to the claims under Article 19 and/or amendments of the international application under Article 34 are received by the International Preliminary Examining Authority before it has begun to draw up a written opinion or the international preliminary examination report, as so amended.

Language for the purposes of international preliminary examination: English

[X] which is the language in which the international application was filed.
[ ] which is the language of a translation furnished for the purposes of international search.
[ ] which is the language of publication of the international application.
[ ] which is the language of the translation (to be) furnished for the purposes of international preliminary examination.

Box No. V ELECTION OF STATES

The applicant hereby elects all eligible States *(that is, all States which have been designated and which are bound by Chapter II of the PCT)*

excluding the following States which the applicant wishes not to elect:

[redacted]ational application No.
[redacted]T/FI99/00153

Box No. VI CHECK LIST

The demand is accompanied by the following elements, in the language referred to in Box No. IV, for the purposes of international preliminary examination:			For International Preliminary Examining Authority use nly: received	not received
1. translation of international application	:	sheets	☐	☐
2. amendments under Article 34	:	sheets	☐	☐
3. copy (or, where required, translation) of amendments under Article 19	:	sheets	☐	☐
4. copy (or, where required, translation) of statement under Article 19	:	sheets	☐	☐
5. letter	:	sheets	☐	☐
6. other *(specify)*	:	sheets	☐	☐

The demand is also accompanied by the item(s) marked below:

1. [X] fee calculation sheet
2. [ ] separate signed power of attorney
3. [ ] copy of general power of attorney; reference number, if any:
4. [ ] statement explaining lack of signature
5. [ ] nucleotide and or amino acid sequence listing in computer readable form
6. [ ] other *(specify)*:

Box No. VII SIGNATURE OF APPLICANT, AGENT OR COMMON REPRESENTATIVE

Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the demand).

For the Applicants

Seppo Laine Oy

Christoffer Sundman

For International Preliminary Examining Authority use only

1. Date of actual receipt of DEMAND:
2. Adjusted date of receipt of demand due to CORRECTIONS under Rule 60.1(b):
3. ☐ The date of receipt of the demand is AFTER the expiration of 19 months from the priority date and item 4 or 5, below, does not apply. ☐ The applicant has been informed accordingly.
4. ☐ The date of receipt of the demand is WITHIN the period of 19 months from the priority date as extended by virtue of Rule 80.5.
5. ☐ Although the date of receipt of the demand is after the expiration f 19 months from the priority date, the delay in arrival is EXCUSED pursuant to Rule 82.

For International Bureau use only

Demand received from IPEA n:

See Notes to the demand form

PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 :
C10J 3/54, B01J 8/26

A1

(11) International Publication Number: WO 99/43768

(43) International Publication Date: 2 September 1999 (02.09.99)

(21) International Application Number: PCT/FI99/00153

(22) International Filing Date: 26 February 1999 (26.02.99)

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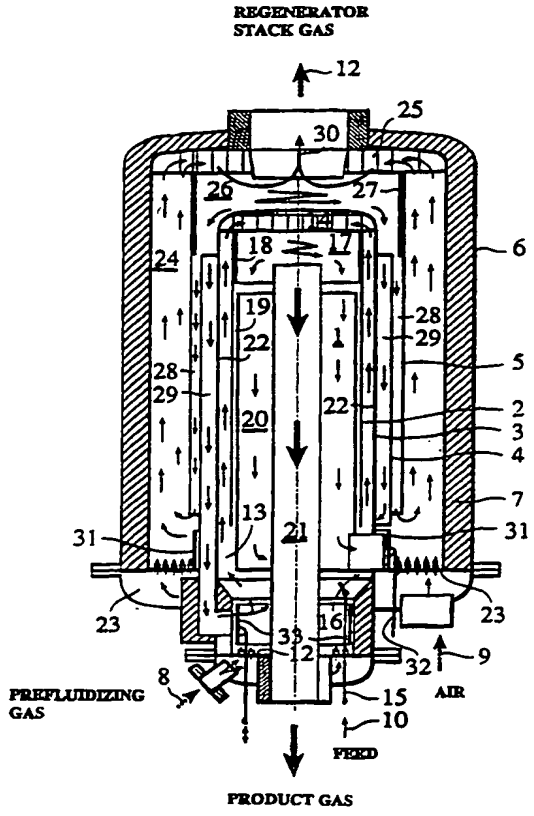
(54) Title: PROCESS FOR PYROLYSING CARBONACEOUS FEEDSTOCKS

(57) Abstract

The present invention concerns a process and an apparatus for thermal conversion of biomass and organic wastes. According to the invention the feedstock is fed into a fluidized–bed reactor (1–3), wherein the feed is converted at an elevated temperature under the influence of particulate matter kept in a fluidized state by a fluidizing gas, the particulate matter is transferred from the reactor to a regenerator (24, 28, 29) for regeneration and then recirculated to the reactor after the regeneration, and the converted hydrocarbon products are recovered from the reactor. Both the reactor (1–3) and the regenerator comprise risers (13, 24) having an axially annular cross section and being equipped with multi–inlet cyclones (14, 17, 25, 26) for the separation of particulate matter. By means of the invention it is possible to produce pyrolysis oil, the quality of which is higher than that of oil produced with the processes of the prior art. The incorporation of multi–inlet cyclones into the reactor configuration reduces gas velocities, reduces the physical size of the cyclone and shortens the residence time of gases in the cyclone.



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PROCESS FOR PYROLYSING CARBONACEOUS FEEDSTOCKS

Background of the invention

Field of the Invention

The present invention relates to thermal conversion processes, in particular to pyrolysis of carbonaceous feedstocks, such as biomass and organic wastes. According to the process, the carbonaceous material is fed into a reactor, wherein the feedstock is converted at moderate temperature in the presence of a heat transfer medium comprising particulate matter. The particulate matter is kept in fluidized state by a fluidizing gas. After pyrolysis, the particulate matter is separated from the hydrocarbon products, it is regenerated by combustion and recirculated to the reactor. The products of the pyrolysis comprise solids, liquids and/or gases which are recovered from the reactor. Optionally the products are subjected to further processing steps, for example by condensation of the vaporized hydrocarbons.

Description of Related Art

The continuing and increasing concern of society for environmental problems related to fossil fuel use and disposal of waste materials has led to increased research into and development and commercialisation of a wide variety of technologies which aim at enhancing the collection, processing and use of materials in an environmentally responsible manner.

At present the expanded use of organic based materials from solid waste streams and forestry residues or purpose grown crops is hindered by the relatively high costs in comparison to the existing infrastructure for employing fossil fuel systems. These high costs are due to both higher feedstock costs and higher conversion costs. The higher conversion costs are related to the well known problem of economy of scale, which is caused by the wide distribution of raw materials which leads to high costs for collection and transport. In terms of biomass conversion, the main goal is to increase the energy

concentration in the final product so as to minimize costs during use. Liquids are also preferred due to the ease of handling, shipping and storing as well as because of their favorable characteristics of use.

In general terms, pyrolysis is a thermal degradation process in which large molecules are broken or cracked into smaller molecules. It can be used to convert a variety of solid or liquid materials into a more readily useable form, and it has, in fact, been employed for the production of charcoal and high viscosity tars from biomass for centuries. The process can be described as a thermal cracking or a depolymerization process in the absence or near absence of oxygen. During the past 10-20 years, the technology has been modified to maximize liquid yields by increasing the heating rate to over 1000 °C/second, reducing the vapour residence time to under 15 seconds and improving the product recovery with a fast quench.

Depending on the feedstock, conventional pyrolysis equipment comprises a drier for the raw material, optionally a mechanical grinder for size reduction, a feed system, a reactor, cyclones for solids removal from the vapour stream, char combustor to provide heat for the reaction and pots for solids removal and recovery system. In addition, a char combustor for process heat is often included. The reactors operate at a slight overpressure.

The above-described process equipment is used for thermal conversion known as "flash" or "fast" pyrolysis. When applied to small biomass particles (<5 mm thick) and temperatures of 400 to 700 °C, liquid yields are as high as 65 to 75 wt-%. The other products of the process are char (10 to 15 wt- %) and non-condensable gases such as methane CH_4, carbon monoxide CO and carbon dioxide CO_2 (10 to 15 wt-%).

The ratio of solids to liquids to gases is determined by both the heating rate and maximum temperature and generally it depends on the specific feedstock. If liquid products are to be maximised it is generally known in the art that intermediate temperatures in the range of 400 to 600 °C and relatively short residence times from 0.5 to 5 seconds are most advantageous. These process conditions lead to high yields, on the order of 65 to 75 weight % of the feedstock.

In the art, heat for the endothermic pyrolysis reaction is produced in a separate boiler or regenerator by combusting the uncondensable gases, tar and combustible solids produced in the process. Heat is transferred from the boiler to the reactor by solid particles, e.g. sand. After the chemical reaction the solids may be covered by tar which is combusted in the boiler. Solids (combustible and sand) are generally removed from the gas stream by one or more cyclones, which are placed following the reactor.

Processes for pyrolysis of carbonaceous materials and equipments used in the processes are discussed in the following patents:

W.M. Hearon et. al, "Preparation of Unsaturated Hydrocarbons from Oxygen Containing Organic Materials" U.S Patent No. 3,148,227 Issued Sept. 8, 1964

C.K. Choi, "Process and Apparatus for Rapid Pyrolysis of Carbonaceous Materials" U.S. Patent No. 4,101,412 issued July 18, 1978

E.L. Capener, M. Low, "Method and Apparatus for converting Solid Organic Material to Fuel Oil and Gas" U.S. Patent No. 4,344,770 issued Aug. 17, 1982

E. Chornet, C. Roy, "Organic Products and Liquid fuels from Lignocellulosic Materials by Vacuum Pyrolysis" Canadian Patent No. 1,163,595 issued March 13, 1984

D.S, Scott "Pyrolysis Process for Biomass" Canadian Patent No. 1,241,541 issued June 6, 1988

D.A, Berg, " Method and Apparatus for Rapid Thermal Processing" Canada Patent No. 1,283,880 issued May 5, 1991

The present technology is hampered by some significant problems. Thus, in order to achieve high product quality it is necessary to remove as high percentage of solids from the gases as possible prior to condensation. Solids remaining in the liquid product significantly reduce product quality by clogging small passages in pumps, fuel lines and nozzles and are

also suspected to lead to increased polymerisation and subsequent increase in viscosity of the liquid fuel.

In the above-mentioned related art, the conventional cyclones and separate reactors and regenerators used have serious limitations restricting their utilization in biomass pyrolysis processes. Thus, the solids are subjected to high velocities in traditional cyclones, which leads to high attrition of both solids and construction materials. The required equipment is large and heavy. Outer surfaces are large, which causes large radiation losses. Vertical distances for solids transport are long, which requires expensive process control equipment.

Summary of the Invention

It is an object of the present invention to eliminate the problems of the prior art and to provide a novel process for pyrolysis of biomass, organic wastes and similar carbonaceous feedstocks.

It is another object of the present invention to provide a novel apparatus for pyrolysis of the afore-mentioned materials.

These and other objects, together with the advantages thereof over known processes, which shall become apparent from specification which follows, are accomplished by the invention as hereinafter described and claimed.

The present invention is based on using a reaction system utilising at least two internally concentrically arranged cylindrical chemical or physical conversion circulating fluidized bed reactors or thermal regenerators comprising multi-inlet cyclones which permits thermal conversion or pyrolyzation of carbonizable material into a number of liquid, solid and gaseous products.

In particular, the process according to the present invention comprises pyrolysing biomass or organic wastes at temperatures in excess of 400 °C in an apparatus including a reactor

with a riser having an axially annular cross section and being equipped with a multi-inlet cyclone for the separation of particulate matter, and a regenerator with a riser having an axially annular cross section and being concentrically fitted in respect of the reactor used, said regenerator also being equipped with a multi-inlet cyclone for separation of regenerated particulate matter. According to the invention, the dipleg of the regenerator communicates with the riser of the reaction unit and with the drying unit.

More specifically, the process according to the present invention is mainly characterized by what is stated in the characterizing part of claim 1.

The apparatus according to the invention is characterized by what is stated in the characterizing part of claim 15.

The present invention achieves considerable advantages. Thus, the traditional problem of high solids content in liquid products has been minimised and it is possible to produce pyrolysis oil, the quality of which is higher than that of oil produced with the prosesses of the prior art. The incorporation of multi-inlet cyclones into the reactor configuration reduces gas velocities, reduces the physical size of the cyclone and shortens the residence time of gases in the cyclone. This directly leads to a reduction in the outer wall area of the hot reactors, which as a consequence leads to less material required and thus a less expensive reactor. Further, lower gas velocities cut down attrition of construction materials.

Next, the invention will be described in more detail by making reference to the appended drawings.

Brief Description of the Drawings

Fig. 1 shows a sectional side view of a preferred embodiment of the pyrolysis apparatus according to the present invention.

Fig. 2 shows a partial sectional view of a simplified structure of another preferred embodiment of the present invention.

Detailed Description of the Invention

Within the scope of the present invention, the terms "thermal conversion" and "pyrolysis" will be used interchangeably to denote a thermal process in which organic material selected from biomass and organic wastes is treated at moderate or high temperatures to produce useful solid, liquid and/or gaseous products.

In the context of thermal conversion, "moderate temperatures" are temperatures in the range of about 400 to about 800 °C, typically up to 600 °C, whereas "high temperatures" are temperatures in excess of 800 °C. The expression "an elevated temperature" covers both temperature ranges.

The terms "regenerator", "solids reheater" and "char combustor" are synonymously used for designating a reaction zone in which heat transfer particles are reheated for burning off any pyrolysis product accumulated on the surface of the particles and for increasing the heat content of the particulate matter.

The pyrolysis system of the present invention performs thermal conversion of carbonizable input material into char, condensable gases and non-condensable gases. The process comprises the steps of drying and grinding the feedstock, thermally converting or pyrolysing the feedstock in the presence of a heat transfer medium, separating products and heat transfer medium, regenerating heat transfer medium and recovering the products of the thermal conversion.

The apparatus comprises typically a feedstock feeder, a flash pyrolysis reactor, fluidizing gas input, multi inlet cyclone(s), sand reheater or regenerator, condensers and liquid storage for the liquids produced by pyrolysis.

Depending on the type and form of material, the input material is first dried to a moisture content of 5 to 25 % but preferably 7 to 12 %, and optionally converted to a finely divided raw material of appropriate size.

A heat transfer medium comprising solids, for example sand but it may also include catalysts, is fluidized by an essentially oxygen-free gas, such as flue gas, in a reactor space, where input material is fed. The heat transfer medium forms a fluidized bed within the reactor space. The fluidized bed can be formed in a reactor of conventional type, such as in a fluidized bed reactor, or the reactor can be a circulating fluidized bed reactor (CFBR). In the latter type the fluidizing velocities are so high that the bed surface is no longer sharply defined but replaced by a zone, wherein the solids content slowly decreases with the height. If particles are fine, this leads to fast fluidization where the solids entrainment occurs at such high rates that, in general, fast fluidized beds can only be maintained by recirculation of the entrained solids via cyclones.

According to the invention, the thermal conversion of the feedstock is performed in a circulating fluidized-bed reactor in which the reaction space, i.e., the fluidization space of the reactor comprises an intershell space of axially annular cross section remaining between two concentrically located cylinders or cones, in which space the feed is first suspended or vaporized into the fluidized bed and subsequently converted into reaction products at an elevated temperature.

The temperature, velocity and mass of the heated bed material are adjusted such that the resulting pyrolysis process maximizes the yield of the desired product. Input material is quickly heated by hot heat transfer media with residence times in the range of 0.01 to 10 seconds, preferably 0.1 to 2 seconds to a final temperature of 450 to 600 °C and is thus thermally converted or pyrolyzed into useable gases and solids.

Solids and bed material are then subsequently removed to percentage of more than 99.5% from the reaction gas by means of a multi-inlet (in the following also "multiport") cyclone, which is located directly above the axially annular reactor riser space. This arrangement makes it possible to shorten the residence time of the reaction, because a multiport cyclone offers faster and more efficient separation of particulate matter from the reaction gas flow over a single-port cyclone. From the cyclone, the particulate matter can be recirculated to a regenerator via a solids return channel, or the downward dipleg, which is formed by an intershell space of axially annular cross section remaining between

two concentrically located cylinders or cones.

According to a preferred embodiment, the regenerator comprises a riser and dipleg of a construction similar to that of the above-described reactor and fitted concentrically around the reactor to provide a compact construction.

In the regenerator, the solids are then fluidized by air or another oxygen-containing gas; the char is combusted while it flows vertically with the air in the surrounding outer regenerator reactor or char combustor. Combustion raises the temperature of the bed material to the operating conditions needed in the reactor.

As mentioned above, the risers and diplegs of both the reactor and the regenerator have axially annular cross sections and are coaxially placed. According to further preferred embodiment of the invention, the drier used for pretreating the feedstock comprises a third riser with a corresponding dipleg concentrically fitted around the combined reactor and regenerator. It is possible to provide channels for internal recirculation of material within at least one of the drier, the reactor and the solids reheater as well as for providing communication between the dipleg of the drier and the riser of the solids reheater and between the dipleg of the regenerator and the riser of the reactor. The dipleg of the reactor can be combined with the risers of both the drier and the regenerator.

The pyrolysis gases produced can be channelled to a series of condensers where they are condensed with the noncondensable gases continuing returning to either the drier or the char combustor for energy recovery.

A wide variety of feedstocks can be used as input materials for the reactor system. The common denominator for the feedstock materials is that it is carbon containing or carbonaceous. These can be broken down into two main categories: biomass and wastes:

The biomass feedstock is preferably selected from forestry residues and thinnings; agricultural residues, such as straw, olive thinnings; energy crops, such as willow, energy hay, Miscanthous; and peat.

The wastes are preferably organic, solid or liquid, and they are selected from refuse derived fuel (RDF); wastes from sawmills, plywood, furniture and other mechanical forestry wastes; plastic wastes; and waste slurries (including industrial and municipal wastes).

An apparatus according to the novel construction comprises an inner reactor of axially annular riser cross section and an outer solids reheater in which contaminated and cooled solid particles can be reheated and returned back to the process. In the following description, the circulating solids are denoted by abbreviation "CS".

Turning now to Figure 1, it can be noted that the apparatus according to the first embodiment of the present invention comprises two concentrically adapted cylindrical CS reactors, separated by an intermediate shell 22 from each other, of which the inner will later be called the "reactor" or "reaction unit" and the outer the "regenerator" or "regeneration unit".

The reactor unit is made from two or, as shown in the figure, preferably three concentrically mounted, essentially cylindrical tubes 1, 2 and 3, whose intertube spaces form spaces 20, 19 and 13 of axially annular cross section. The tubes may be made from steel or an equivalent alloy. Among these, the desired reaction is carried out in the space 13. The tubes are mounted with their longitudinal axes aligned concentrically vertical. Above the axially annular riser space 13, as a continuation of tubes 2 and 3, is mounted a multiport cyclone 14, 17 having louvered vanes 14 fixed to its outer wall. The cyclone is provided with a center tube 21 for removal of the product gas, while transfer channels 19 and 20 are provided in the inner space of the inner steel tube 3 for removal of the solids separated from the gaseous phase in the cyclone.

Outside the reactor outer shell 3, the regenerator unit comprises three concentrically mounted, essentially cylindrical tubes 4, 5 and 6, whose intertube spaces form spaces 29, 28 and 24 of axially annular cross section. Among these, solids reheating is carried out in the space 24. From inside, the pressure shell 6 is lined with an insulating material layer 7 in order to maintain the shell temperature at a reasonable level for shell strength. In a similar fashion as in the reactor, above the axially annular space 24 is mounted a

multiport cyclone 25, 26, whose vanes are attached either to the cylindrical tube 5 or the pressure shell 6. The cyclone is provided with a center tube 30 for the removal of the stack gas formed in the regenerator, while transfer channels 28 and 29 are provided by means of steel tubes 5 and 6 for removal of the catalytic solids separated from the gas phase in the cyclone.

The fluidization gas flow of the reactor is denoted in the diagram by reference numeral 8. The gas flow 8 enters the reaction space through a fluidization bottom 12 above which it is first mixed with the catalyst entering via a return channel 20 via a valve 31, and then higher in the reactor riser, with the feed flow 10 injected via nozzles 17 or fed using a screw feeder via channels 16 into the reaction space. The mixed gas flows 8 and 10 move in a gaseous phase along the axially annular riser 13 simultaneously carrying the entrained solids therewith into the vanes 14 of the reactor cyclone. The catalyst releases heat into the feed vaporization and the reaction occurring in the riser 13, whereby its temperature falls. From the vanes 14, the gas and entrained solids enter tangentially the interior of the inner reactor cyclone chamber 17, where the solids are separated by impinging on cyclone inner wall 18 and falling into the solids transfer channels 19 and 20. When required, a portion of the solids can be returned as an overflow back to the reactor bottom section via an axially annular, internal recirculation channel 19. While the channel 19 is not essential to the function of the apparatus, it may in some cases be advantageous to the reaction. In the channel 20, the solids dribble downward in a dense phase, whereby the mixing of the gas flows between the reactor and the regenerator via the solids transfer channel 20 will be inhibited. The gas flow 11 entering the reactor cyclone exits the reactor via the center tube 21 of the inner cyclone. The solids flow from the reactor into the regenerator is controlled by means of a valve 31 equipped with a cylindrical control element, which is arranged mechanically movable by means of bars 32.

The regenerator is adapted about the reactor so that these units are separated from each other by a transfer channel 29 filled with solids in a dense phase. In a similar fashion with the reactor, the regenerator is located in the intershell riser space remaining between two cylindrical envelope surfaces formed by the apparatus shell and the reactor tube

mounted inside the shell. Between said reactor tube and said outer cylindrical shell structure of the reactor is further mounted a cylindrical wall to provide said solids transfer channel 29. An oxygen-containing gas flow (e.g. air) 9 enters the solids reheater via a fluidizing distributor bottom 23 and rises in the axially annular riser channel 24 simultaneously therewith carrying the solids into the vanes 25 of the regenerator cyclone. In the reheater, coke possibly accumulated on the surface of the solids and organic compounds penetrated in the pores thereof are oxidized, that is, burned in the riser channel 24, whereby the solids temperature is elevated. The regenerator cyclone chamber 26 is located above the reactor proper. In the cyclone chamber 26, the solids are separated by impinging on the cyclone wall 27 and subsequently fall into channels 28 and 29. The return channel 29 passes the catalytic solids back to the reactor. That excess portion of the solids which fails to enter the return channel will fall back to the regenerator bottom section as an overflow via the channel 28. The particulate matter is advantageously kept in a fluidized state during its passage in the internal return channel, whereby a control valve is redundant. The stack gas 12 of the regenerator is removed via the central tube 30 of the regenerator cyclone. The solids dribbling slowly downward in the return channel 29 in a dense phase prevent communication between the gas spaces of the reactor and the regenerator. The solids flow rate from the regenerator to the reactor is controlled by moving the cylindrical control element of a valve 33 mechanically via bars 34 connected thereto.

For wet materials such as slurries, saw dust etc., comprising finely-divided solid matter, the embodiment shown in Fig. 2 can be used. It comprises a pyrolysis apparatus consisting of a reactor 41 and a dipleg 42. The reactor includes a channel 52 for internal recirculation of unreacted biomass and solids. Said channel is preferably fitted between the reactor and the dipleg. The axial cross-sections of the riser, the dipleg and the recirculation channel are annular. A regenerator or solids reheater 43 having an axially annular cross-section is concentrically fitted within the reaction unit 41, 42, 52. The regenerator includes a channel 44 for internal recirculation of treated matter and a central cylindrical dipleg 45 communicating with the riser of the reactor 41. A drier or drying unit 46-48 is concentrically fitted about the reaction unit 41, 42, 52. The construction of the drier is similar to that of the reactor and the regenerator comprising a channel for internal

recirculation 47 having an axially annular cross-section and a dipleg 48 of similar cross-section.

Each of the risers having axially annular cross-sections are provided with multi-inlet cyclones 49 - 51 at the top (as a continuation of the tubes defining the risers), for separating solids and gas.

The connections and communicating channels between the drying unit, the reactor and the reheater are shown in Figure 2. As readily seen, a channel 53 formed in the lower part of the apparatus will provide contact between the dipleg 45 of the reheater and the risers 41, 46 of the reactor and the drier. The riser of the reactor 41 is also connected to the dipleg of the drier 48. The flux of material between the diplegs of the various sections within said communicating channels are adjusted by means of control valves 54 - 57.

For fluidizing the solids in the reactor 41, flue gases obtained, for example, from the reheater can be used. Flue gases are also preferably used for drying of the feedstock. Air and possibly uncondensed pyrogases (from the reactor) can be fed into the reheater 43 for burning off pyrolysis products on the surface of the solids.

The gaseous products obtained from the reactor can be condensed in a condenser cascade (not shown) to produce liquid pyrolysis products, useful as, e.g., fuels.

Example

Forestry residues are collected and shipped to the pyrolysis process plant. For the apparatus shown in Figure 1, the feedstock is dried in a separate drier (not shown) to an appropriate moisture content, normally less than 15 weight percent and ground, chopped or hammered to an appropriate thickness and length before being fed into the reactor system by a screw feeder.

In the embodiment shown in Figure 2, the wet feedstock is fed to the drying section, in which it is dried to desired moisture content, at least a part of the material being

recirculated through channel 47. Humid flue gas is released from the drier and a part of the dried material is conducted via the dipleg to the reactor wherein it is mixed with the particulate heat transfer matter (e.g. sand).

Either flue gases from the sand reheater / regenerator 43 or non-condensible gases from the liquid collection section are compressed and fed into the reactor 41 for bed fluidization. The input material is fed into the reactor assembly at the bottom of the reactor at the point where the heated bed material is returned to the reactor.

In either alternative the input particles are then rapidly heated in 0.5 to 5 seconds to the operational temperature of 450 to 600 °C where they undergo the thermal conversion or pyrolysis reaction forming a mixture of condensible vapors, solids and noncondesible gases. The solid char and bed material are removed from the gas stream by a multi-inlet port cyclone and the pyrolysis vapors are directed into a series of condensers where the temperature is lowered from a temperature in the range of 450 to 600 °C to a final temperature of 40 to 60 °C. The vapors are condensed and mixed to give a final yield of liquid from 50 to 75 weight percent. Non-condensible gases which are comprised mostly of carbone dioxide, carbon monoxide and methane are utilized in either the drier as a source of heat or the regenerator as a source of heat or as the fluidizing gas.

In the regenerator section 43, the bed material is heated by oxidising combustible solid char removed from the gas stream by the multi inlet port cyclone and also if desired by noncondensable gases from condensers. As fluidizing gas air (ambient air or hot humid air from drier) is used. Flue gases from regenerator is used for pyrolysis reactor fluidizing gas and/or for drying of feedstock together with solid char.

Claims:

1. A process for thermal conversion of carbonaceous feedstocks selected from biomass and organic wastes, in which method

- the feedstock is fed into a fluidized-bed reactor (1-3; 41, 42, 52), wherein the feed is converted at an elevated temperature under the influence of particulate matter kept in a fluidized state by a fluidizing gas,
- the particulate matter is transferred from the reactor to a regenerator (24, 28, 29; 43-45) for regeneration and then recirculated to the reactor after the regeneration, and
- the converted hydrocarbon products are recovered from the reactor,

characterized by using

- a reactor (1-3), which comprises a riser (13; 41) having an axially annular cross section and being equipped with a multi-inlet cyclone (14, 17; 50) for the separation of particulate matter, and
- a regenerator (24, 28, 29; 43-45), which comprises a riser (24) having an axially annular cross section and being concentrically fitted in respect of the reactor used, said regenerator being equipped with a multi-inlet cyclone (25, 26; 51) for separation of regenerated particulate matter.

2. The process according to claim 1, wherein the reactor comprises an intershell riser space (13; 41) formed between two concentrically located cylindrical and/or conical envelope surfaces.

3. The process according to claim 1 or 2, wherein the vapour residence time of said process is 0.1 - 5 s.

4. The process according to any of claims 1 to 3, comprising using a multiport cyclone (17) equipped with louvered vanes (14).

5. The process according to any of claims 1 to 4, wherein the reactor (41, 42, 52) is a circulating fluidized-bed reactor optionally having a channel (52) for internal circulation.

6. The process according to any of claims 1 to 5, wherein the regenerator (43-45) is provided with a channel (44) for internal recirculation.

7. The process according to any of claims 1 to 6, wherein the regenerator is provided with a dipleg (29; 45), which communicates with the riser of the reactor.

8. The process according to any of claims 1 to 7, wherein the feedstock is dried in a drier (46-48) comprising a riser (46) having an axially annular cross section and being equipped with a multi-inlet cyclone (49) for the separation of dried matter from vaporized gases.

9. The process according to claim 8, wherein the drier is provided with a dipleg (48), which communicates with the riser (41) of the regenerator.

10. The process according to claim 8 or 9, wherein the drier (46-48) is provided with a channel (47) for internal circulation.

11. The process according to any of claims 8 to 10, wherein the dipleg (45) of the regenerator communicates with the riser of the drier (46).

12. The process according to any of the preceding claims, wherein the feedstock is thermally converted at a temperature of 400 - 1000 °C.

13. The process according to any of the preceding claims, wherein the feedstock is selected from forestry residues and thinnings, agricultural residues, energy crops, peat, refuse derived fuel, wastes from sawmills, plywood, furniture and other mechanical forestry wastes, plastic wastes and waste slurries.

14. The process according to claim 13, wherein the feedstock is selected from straw, olive thinnings, willow, energy hay and Miscanthous.

15. An apparatus for thermally converting carbonaceous feedstocks, said apparatus

comprising

- a drying unit (46-48) for drying the feedstock,
- a reaction unit (41, 42, 52) in which the feedstock is contacted with hot, fluidized-state particulate matter, and
- a regenerator unit (43-45) for regeneration of the particulate matter contaminated in the first unit process,

characterized in that

- the reaction unit comprises a riser (41) with an axially annular cross section and having a multi-inlet cyclone (50) for separating solids from gas, and
- the regenerator unit comprises a circulating fluidized-bed reactor (43, 44) and a dipleg (45) fitted about the reaction unit (41, 42, 52) in a symmetrically concentric fashion, said riser (43) having an axially annular cross section and being equipped with a multi-inlet cyclone (51) for separation of solids from gas, said dipleg (45) of the regenerator unit communicating with the risers (41, 46) of the reaction unit and with the drying unit.

16. The apparatus according to claim 15, wherein the regenerator unit (43-45) comprises a channel (44) for internal recirculation of solid matter within the regenerator unit.

17. The apparatus according to claim 15 or 16, wherein the reaction unit (41, 42, 52) comprises a channel (52) for internal recirculation of solid matter within the reactor.

18. The apparatus according to any of claims 15 to 17, wherein the drying unit (46-48) comprises a riser (46) fitted about the reaction unit in a symmetrically concentric fashion, said riser having an axially annular cross section.

19. The apparatus according to claim 18, wherein the drying unit (46-48) comprises a dipleg having an axially annular cross section and communicating with the riser (41) of the reaction unit.

20. The apparatus according to claim 18 or 19, wherein the riser (46) of the drying unit is equipped with a gas and solids separating means formed by a multi-inlet cyclone (49).

REGENERATOR
STACK GAS

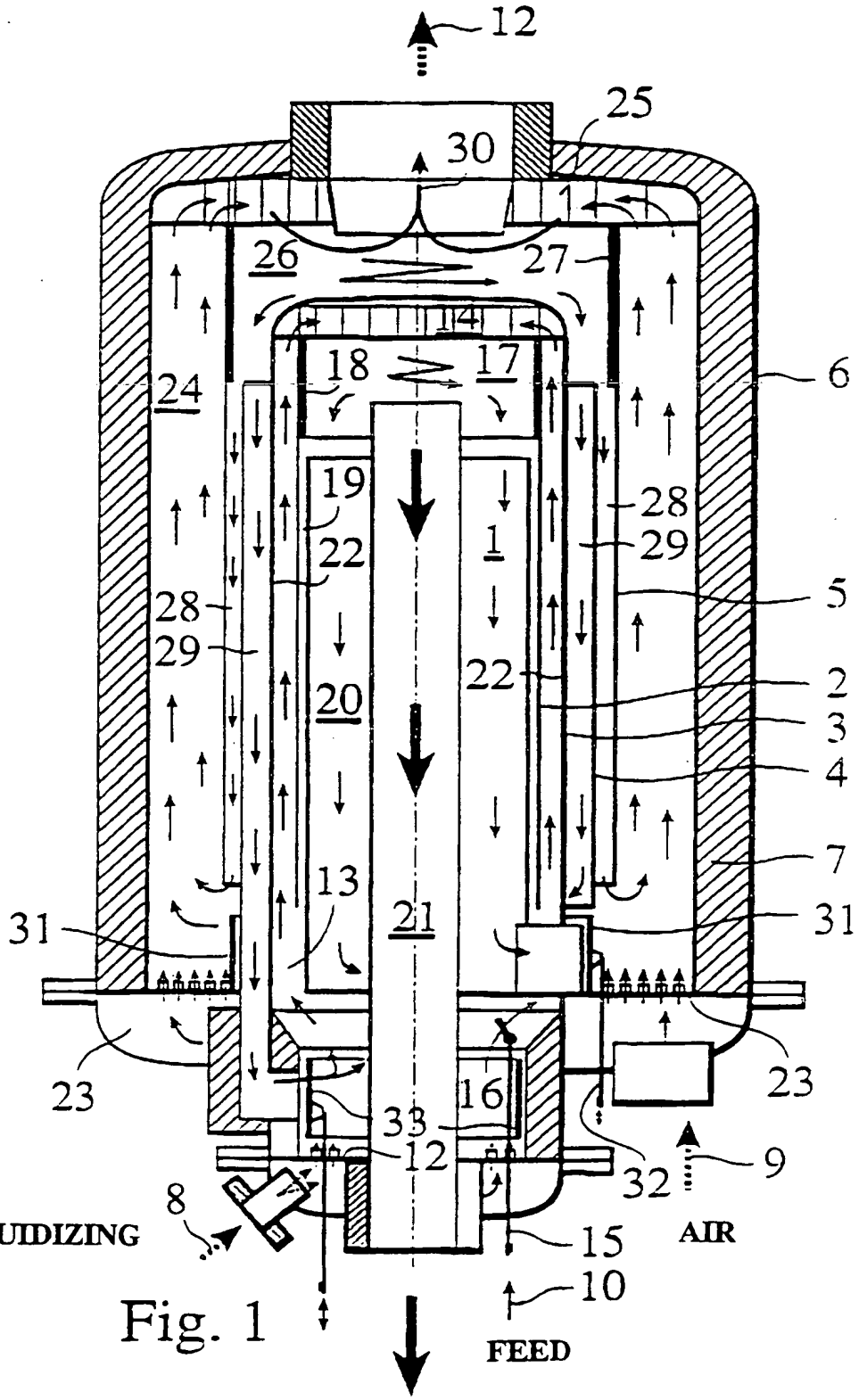

Fig. 1

PRODUCT GAS

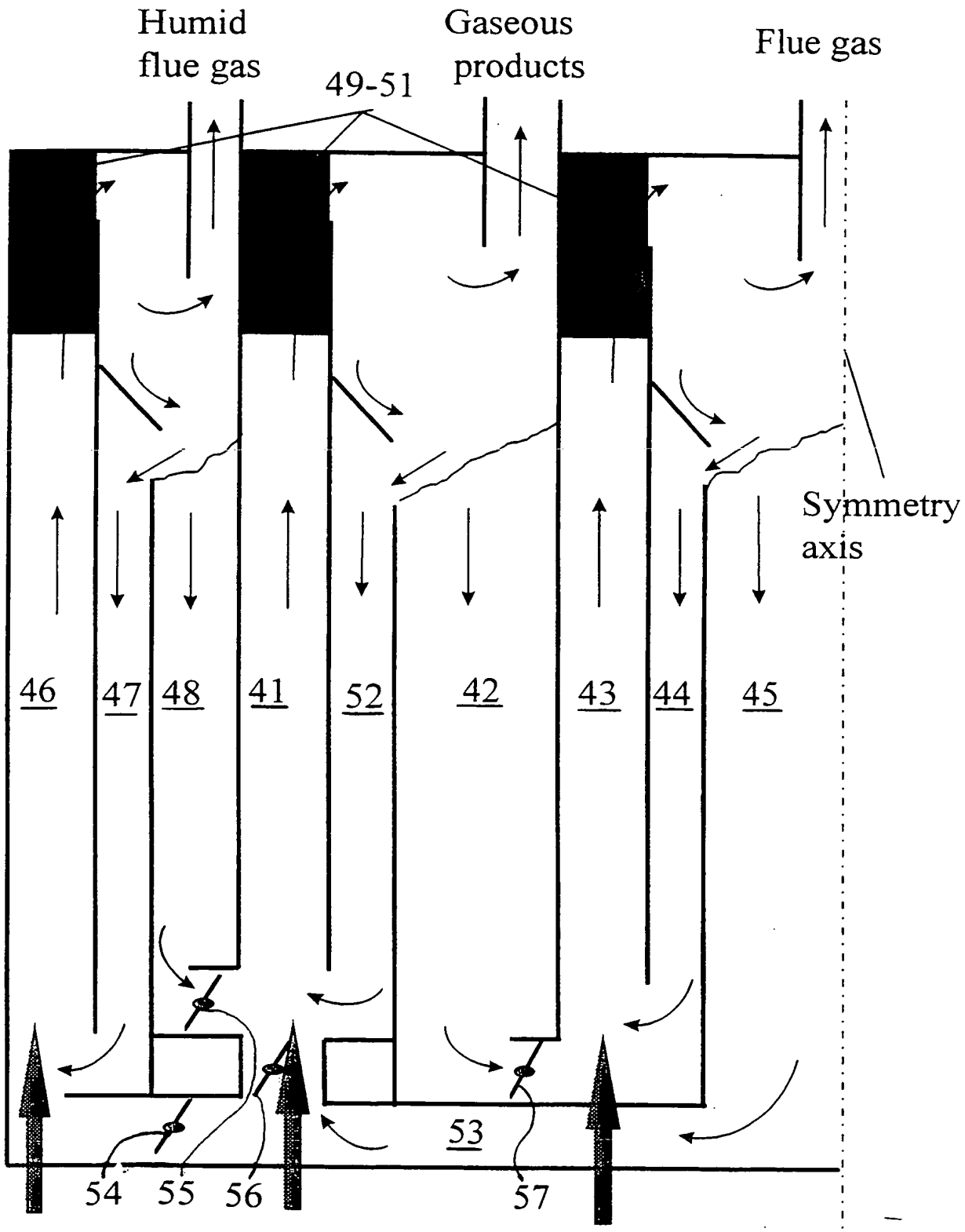
Humid flue gas
Gaseous products
Flue gas
49-51
Symmetry axis
46
47
48
41
52
42
43
44
45
53
54
55
56
57
Wet biomass + flue gas
Flue gas
Air + uncondensed pyrogases

Fig. 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 99/00153

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: C10J 3/54, B01J 8/26
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: C10J, B01J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPODOC,WPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,X	WO 9808600 A1 (NESTE OY), 5 March 1998 (05.03.98) --	1-20
A	US 2525925 A (DONALD E. MARSHALL ET AL), 17 October 1950 (17.10.50) --	1-20
A	DE 3217422 A1 (FRITZ WERNER INDUSTRIE-AUSRüSTUNGEN GMBH), 10 November 1983 (10.11.83) --	1-20
A	US 4152393 A (JAMES L. CALLAHAN ET AL), 1 May 1979 (01.05.79) -- --------	1-20

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents: --

"A" document defining the general state of the art which is not considered to be of particular relevance

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
5 July 1999	09 -07- 1999
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Bertil Dahl/MP Telephone No. +46 8 782 25 00

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

01/06/99

International application No.
PCT/FI 99/00153

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9808600 A1	05/03/98	AU 4017897 A	19/03/98
		EP 0888174 A	07/01/99
		FI 101156 B	30/04/98
		FI 963404 A	01/03/98
US 2525925 A	17/10/50	NONE	
DE 3217422 A1	10/11/83	NONE	
US 4152393 A	01/05/79	US 4341717 A	27/07/82